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# MULTIMEDIA UNIVERSITY

## FINAL EXAMINATION

TRIMESTER 1, 2017/2018

### PME0016 – MECHANICS

(Foundation in Engineering - All Sections / Groups)

16 OCTOBER 2017  
2.30 P.M – 4.30 P.M  
(2 Hours)

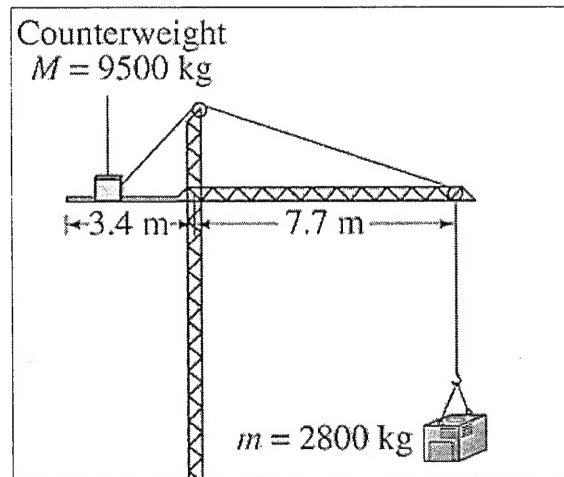
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#### INSTRUCTIONS TO STUDENTS

1. This question paper consists of 7 pages.
2. Answer **ALL** questions. The distribution of the marks for each question is given.
3. Write all your answers in the Answer Booklet provided.
4. All necessary workings **MUST** be shown.

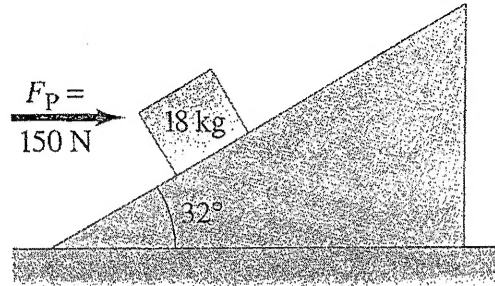
**QUESTION 1 (10 Marks)**

- a) (i) State the two conditions for equilibrium. [1 mark]
- (ii) A ladder, leaning against a wall, makes a  $60^\circ$  angle with the ground. If a man stands on this ladder, would the ladder more likely to slip when he is at the top or near the bottom of the ladder? Explain your answer. [2.5 marks]
- b) A tower crane must always be carefully balanced so that there is no net torque tending to tip it. A particular crane at a building site is about to lift a 2800 kg air conditioning unit. The crane's dimensions are shown in **Figure Q1(b)**.
- (i) Draw the free body diagram of the tower crane. [1.5 mark]
- (ii) Where should the crane's 9500 kg counterweight be placed when the load is lifted from the ground? [2.5 marks]
- (iii) Determine the maximum load that can be lifted with this counterweight when it is placed at its full extent. Ignore the mass of the beam. [2.5 marks]

**Figure Q1(b)****Continued...**

**QUESTION 2 (10 MARKS)**

- a) A 18.0 kg block is placed on an inclined plane as shown in **Figure Q2(a)** below. Given that the coefficient of friction between the block and the inclined surface is  $\mu_k = 0.11$ . Please calculate the following:

**Figure Q2(a)**

- (i) the work done by the horizontal force  $F_P = 150 \text{ N}$  on the 18.0 kg block when the force pushes the block 5.3 m up along the rough surface. [1 mark]
  - (ii) the work done by the gravitational force on the block during this displacement. [1 mark]
  - (iii) the work done on the friction force. [3 marks]
  - (iv) the work done by the normal force. [1 mark]
  - (v) the net work done on the block. [1 mark]
  - (vi) the speed of the block (assume that it is zero initially) after this displacement. [1 mark]
- b) If you stand on a bathroom scale, the spring inside the scale compresses 0.65 mm, and it tells you your weight is 778 N. Now if you jump onto scale from a height of 1.5 m, calculate your weight reading from the scale. [2 marks]

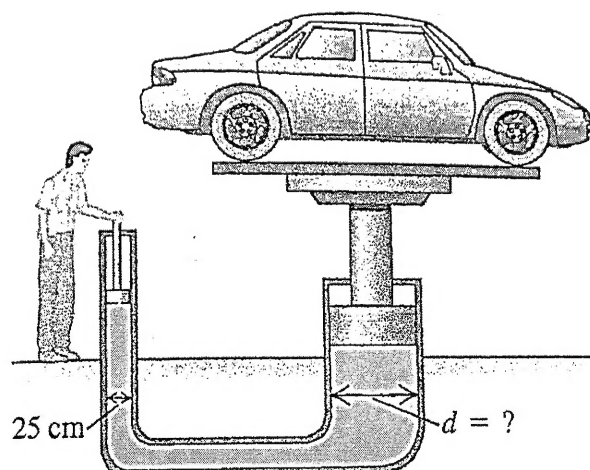
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**QUESTION 3 (10 Marks)**

- a) The angle through which a rotating wheel has turned in time  $t$  is given by  $\theta = 8.5t - 15.0t^2 + 1.6t^4$ , where  $\theta$  is in radians and  $t$  is in seconds.
- Determine the expression for the instantaneous angular velocity  $\omega$ . [1 mark]
  - Determine the expression for the instantaneous angular acceleration  $\alpha$ . [1 mark]
  - Evaluate the value for  $\omega$  and  $\alpha$  at  $t = 3.0$  s. [2 marks]
  - What is the average angular velocity between  $t = 2.0$  s and  $t = 3.0$  s? [2 marks]
  - What is the average angular acceleration between  $t = 2.0$  s and  $t = 3.0$  s? [2 marks]
- b) Two solid spheres simultaneously start rolling (from rest) down an incline. One sphere has twice the radius and twice the mass of the other.
- Which reaches the bottom of the incline first? [1 mark]
  - Which has the greater total kinetic energy at the bottom? [1 mark]

**QUESTION 4 (10 MARKS)**

- a) You are designing a hydraulic lift for an automobile garage. It will consist of two oil-filled cylindrical pipes of different diameters. A worker pushes down on a piston at one end, raising the car on a platform at the other end, as shown in **Figure Q4(a)**. To handle a full range of jobs, you must be able to lift cars up to 3800 kg, plus the 550 kg platform on which they are parked. To avoid injury to your workers, the maximum amount of force a worker should need to exert is 150 N.

**Figure Q4(a)**

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- (i) Calculate the diameter of the pipe under the platform. [2.5 marks]
- (ii) If the worker pushes down with a stroke 60 cm long, determine how high will he raise the car at the other end. [2 marks]
- b) A hollow plastic sphere is held below the surface of freshwater lake by a cord anchored to the bottom of the lake. The sphere has a volume of  $0.85 \text{ m}^3$  and the tension in the cord is 1050 N. Given the density of freshwater is  $1.0 \times 10^3 \text{ kgm}^{-3}$ .
- (i) Calculate the buoyant force exerted by the water on the sphere. [1 mark]
- (ii) Determine the mass of the sphere. [2 marks]
- (iii) The cord breaks and the sphere rises to the surface. When the sphere comes to rest, calculate the percentage of its volume will be submerged. [2.5 marks]

### QUESTION 5 (10 Marks)

At  $t = 0$ , a 785 g mass at rest on the end of a horizontal spring  $k = 184 \text{ N/m}$  is struck a hammer which gives it an initial speed of 2.26 m/s. Determine

- a) the period and frequency of the motion [3 marks]
- b) the amplitude [1.5 marks]
- c) the maximum acceleration [1.5 marks]
- d) the position as a function of time [1.5 marks]
- e) the kinetic energy when  $x = 0.40A$  where A is the amplitude. [2.5 marks]

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## APPENDIX I:

## LIST OF PHYSICAL CONSTANTS

Electron mass,	$m_e$	=	$9.11 \times 10^{-31} \text{ kg}$
Proton mass,	$m_p$	=	$1.67 \times 10^{-27} \text{ kg}$
Neutron mass,	$m_n$	=	$1.67 \times 10^{-27} \text{ kg}$
Magnitude of the electron charge,	$e$	=	$1.602 \times 10^{-19} \text{ C}$
Universal gravitational constant,	$G$	=	$6.67 \times 10^{-11} \text{ N.m}^2/\text{kg}^2$
Universal gas constant,	$R$	=	$8.314 \text{ J/mol.K}$
Hydrogen ground state,	$E_0$	=	$13.6 \text{ eV}$
Boltzmann's constant,	$k_B$	=	$1.38 \times 10^{-23} \text{ J/K}$
Compton wavelength,	$\lambda_c$	=	$2.426 \times 10^{-12} \text{ m}$
Planck's constant,	$h$	=	$6.63 \times 10^{-34} \text{ J.s}$
		=	$4.14 \times 10^{-15} \text{ eV.s}$
Speed of light in vacuum,	$c$	=	$3.0 \times 10^8 \text{ m/s}$
Rydberg constant,	$R_H$	=	$1.097 \times 10^7 \text{ m}^{-1}$
Acceleration due to gravity of earth,	$g$	=	$9.80 \text{ m/s}^2$
Unified atomic mass unit,	$1 \text{ u}$	=	$931.5 \text{ MeV}/c^2$
		=	$1.66 \times 10^{-27} \text{ kg}$
1 electron volt,	$1 \text{ eV}$	=	$1.60 \times 10^{-19} \text{ J}$
Avogadro's number,	$N_A$	=	$6.022 \times 10^{23} \text{ mol}^{-1}$
Threshold of intensity of hearing,	$I_0$	=	$1.0 \times 10^{-12} \text{ W/m}^2$
Coulomb constant,	$k = \frac{1}{4\pi\epsilon_0}$	=	$9.0 \times 10^9 \text{ N.m}^2/\text{C}^2$
Permittivity of free space,	$\epsilon_0$	=	$8.85 \times 10^{-12} \text{ C}^2/\text{N.m}$
Permeability of free space,	$\mu_0$	=	$4\pi \times 10^{-7} \text{ T.m/A}$
1 atmosphere pressure,	$1 \text{ atm}$	=	$1.0 \times 10^5 \text{ N/m}^2$
		=	$1.0 \times 10^5 \text{ Pa}$
Wein's displacement constant		=	$0.2898 \times 10^{-2} \text{ m.K}$
Speed of Sound in Air		=	$343 \text{ m/s}$
Refractive index of air/vacuum	$n$	=	$1.0$
Earth: Mass,	$M_E$	=	$5.97 \times 10^{24} \text{ kg}$
Radius (mean),	$R_E$	=	$6.38 \times 10^3 \text{ km}$
Moon: Mass,	$M_M$	=	$7.35 \times 10^{22} \text{ kg}$
Radius (mean),	$R_M$	=	$1.74 \times 10^3 \text{ km}$
Sun: Mass,	$M_S$	=	$1.99 \times 10^{30} \text{ kg}$
Radius (mean),	$R_S$	=	$6.96 \times 10^5 \text{ km}$
Earth-Sun distance (mean),		=	$149.6 \times 10^6 \text{ km}$
Earth-Moon distance (mean),		=	$384 \times 10^3 \text{ km}$

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## APPENDIX II:

## LIST OF FORMULAS IN MECHANICS

$y = kx^n$ $\frac{dy}{dx} = knx^{n-1}$	$\sin \theta = \frac{\text{opposite}}{\text{hypotenuse}}$	$\cos \theta = \frac{\text{adjacent}}{\text{hypotenuse}}$	$\tan \theta = \frac{\text{opposite}}{\text{adjacent}}$
$v = v_o + gt$ $y - y_o = \left( \frac{v_o + v}{2} \right) t$ $a_c = \frac{v^2}{r}$ $\tau = r \times F$ $L = r \times p = I\omega$ $T_s = 2\pi \sqrt{\frac{m}{k}}$ $x = A \cos \omega t$ $v = -\omega A \sin \omega t$ $a = -\omega^2 A \cos \omega t$ $v = \frac{\Delta x}{\Delta t}$ $v = v_o + at$ $x - x_o = \left( \frac{v_o + v}{2} \right) t$ $W = mg$ $p = mv$ $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$ $K = \frac{1}{2} mv^2$	$y - y_o = v_o t + \frac{1}{2} gt^2$ $F_g = G \frac{m_1 m_2}{r^2}$ $\sum \tau = \tau_{net} = I\alpha$ $K = \frac{1}{2} I\omega^2$ $T_p = 2\pi \sqrt{\frac{l}{g}}$ $x = A \sin \omega t$ $v = \omega A \cos \omega t$ $a = -\omega^2 A \sin \omega t$ $a = \frac{\Delta v}{\Delta t}$ $x - x_o = v_o t + \frac{1}{2} at^2$ $\sum F = F_{net} = ma$ $\sum F = \frac{\Delta p}{\Delta t}$ $m_1 u_1 + m_2 u_2 = (m_1 + m_2) v$ $PE_s = \frac{1}{2} kx^2$	$v^2 = v_o^2 + 2g(y - y_o)$ $U_g = -G \frac{m_1 m_2}{r}$ $I = \sum mr^2$ $T = \frac{2\pi}{\omega} = \frac{1}{f}$ $v = r\omega$ $T = \frac{2\pi}{\omega} = \frac{1}{f}$ $f_s \leq \mu_s F_N$ $P = \frac{W}{t} = \frac{E}{t} = \frac{Fd}{t} = F\bar{v}$ $F_s = -kx$	$v = r\omega$ $v = r\omega$ $f_k = \mu_k F_N$ $PE_G = mgy$

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